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Chapter 4

Variation in case-mix between hospitals treating colorectal cancer patients in the Netherlands

N. E. Kolfschoten[1], P.J. Marang-van de Mheen[2], G.A. Gooiker[1], E.H. Eddes[3], J. Kievit[1,2], R.A.E.M Tollenaar[1], M.W.J.M. Wouters[1,4], on behalf of the Dutch Surgical Colorectal Audit group*

[1] Leiden University Medical Centre, Dept of Surgery
[2] Leiden University Medical Center, Dept of Medical Decision Making
[3] Deventer Hospital, Dept of Surgery
[4] Netherlands Cancer Institute-Antoni van Leeuwenhoek Hospital, Dept of Surgical Oncology
* the Dutch Surgical Colorectal Audit group: W.A. Bemelman, O.R.C. Busch, R.M. van Dam, E. van der Harst, M.L.E.A. Jansen-Landheer, Th.M. Karsten, J.H.J.M. van Krieken, W.G.T. Kuijpers, V.E. Lemmens, E.R. Manusama, W.J.H.J Meijerink, H.J.T. Rutten, T. Wiggers, C.J.H. van de Velde.

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Abstract

Aims
The purpose of this study was to determine how expected mortality based on case-mix varies between colorectal cancer patients treated in non-teaching, teaching and university hospitals, or high, intermediate and low-volume hospitals in the Netherlands.

Material and methods
We used the database of the Dutch Surgical Colorectal Audit 2010. Factors predicting mortality after colon and rectum carcinoma resections were identified using logistic regression models. Using these models, expected mortality was calculated for each patient.

Results
8580 patients treated in 90 hospitals were included in the analysis. For colon carcinoma, hospitals' expected mortality ranged from 1.5 to 14%. Average expected mortality was lower in patients treated in high-volume hospitals than in low-volume hospitals (5.0 vs. 4.3%, $p<0.05$). For rectum carcinoma, hospitals expected mortality varied from 0.5 to 7.5%. Average expected mortality was higher in patients treated in non-teaching and teaching hospitals than in university hospitals (2.7 and 2.3vs. 1.3%, $p<0.01$). Furthermore, rectum carcinoma patients treated in high-volume hospitals had a higher expected mortality than patients treated in low-volume hospitals (2.6 vs. 2.2% $p<0.05$). We found no differences in risk-adjusted mortality.

Conclusions
High-risk patients are not evenly distributed between hospitals. Using the expected mortality as an integrated measure for case-mix can help to gain insight in where high-risk patients go. The large variation in expected mortality between individual hospitals, hospital types and volume groups underlines the need for risk-adjustment when comparing hospital performances.

Introduction

Colorectal carcinoma is the second most common cancer related cause of death in western countries, and incidence is rising. Surgical resection is still the cornerstone of treatment, though associated with a considerable peri-operative risk. It is also known that outcome after colorectal resections, especially postoperative mortality varies between hospitals[1]. Although differences in mortality rates are often studied with a focus on the inverse relationship with procedural volume[2, 3] similar variations have been reported between different types of hospitals, such as teaching and non-teaching hospitals[4-6].
Part of these variations can be explained by differences in case-mix (patient and tumour characteristics). Therefore case-mix correction is considered to be essential for reliable and valid outcome comparisons[7]. In the last decade, several countries have started nation-wide colorectal audit programs, which are coordinated on a European level by the EURECCA project of the European Society of Surgical Oncology. Considering this increasing interest in outcome measurements, information on differences in case-mix between (different types of) hospitals becomes more and more important.

A commonly used method for case-mix correction is the Observed/Expected mortality rate[8, 9], in which the observed mortality is the number of deaths in a hospital or group of hospitals, and the expected mortality is the sum of the patients' estimated probabilities for mortality, based on their case-mix factors. Previous studies have described variation in the distribution of specific case-mix factors between teaching and non-teaching hospitals, and high- and low-volume hospitals, with varying results[4-6]. However, to date, variations in expected mortality rates between different types of hospitals have not been studied in detail. More insight in the distribution of expected mortality can assist health care providers in recognizing high-risk patients treated in their hospital and focus quality improvement efforts on these patients.

Following the initiatives in Scandinavian countries and in the United Kingdom, the Dutch Surgical Colorectal Audit (DSCA) was initiated in 2009[10]. The DSCA is a nation wide, web based, interactive database in which detailed patient, tumour, diagnostic, procedural and outcome data are registered of patients who undergo a resection of a primary colorectal carcinoma in the Netherlands. This database gave us the opportunity to further investigate differences in expected mortality based on differences in case-mix between patients treated in different types of hospitals in the Netherlands.
The purpose of this study was to determine

1) which case-mix factors are predictors for postoperative mortality after the resection of colon and rectum carcinomas in the Netherlands
2) how expected mortality based on case-mix factors differs between individual as well as different types of hospitals: non-teaching, teaching and university hospitals and high-, intermediate and low-volume hospitals

3) which patient and tumour characteristics are responsible for these differences in expected mortality

Patients and methods

Patients

About 93% of all patients who underwent a resection of a primary colorectal carcinoma in the Netherlands from 1st of January 2010 until 31st of December 2010 were included in the DSCA [www.dsca.nl] on March 15th 2011. All Dutch hospitals participated. Data entry was web-based in a highly secured database. All participating hospitals appointed a surgeon who was responsible for the data-entry. Weekly feedback information on number of patients entered, number of registered patient files, and overall completeness of patient files combined with benchmarked performance indicators were placed online in a secured internet page, accessible for the hospital only. To secure data quality, hospitals received data quality reports throughout the year, summing all patients with inconsistent or unusual data combinations, identified by a total of 70 queries. The responsible surgeon was asked to verify the data of these patients and to correct the data when indicated.
Patients treated for a recurrence of a colorectal carcinoma or multiple synchronous colorectal tumours were excluded. Records that did not contain a tumour location, a date of surgery or did not specify if the patient had left the hospital alive were excluded.

Definitions

Case-mix factors registered in the DSCA were age, gender, comorbidity (Charlson-comorbidity index), previous abdominal surgery, Body Mass Index, American Society of Anaesthesiologists (ASA) classification, TNM stage, neoadjuvant (chemo) radiation therapy, preoperative tumour complications, urgency of the resection, type of resection, additional resection for tumour invasion and/or metastasis.

Postoperative mortality was defined as mortality during the same hospital admission of the surgical resection or within 30 days after resection.
Hospitals were categorized as low-, medium- or high-volume, according to the criteria of the Dutch Cancer Society[1]. For colon carcinoma the categories are: less than 50, 50 to 100, and 100 or more patients treated surgically in the year 2010. For rectum carcinoma the categories are: less than 50 patients and 50 or more patients treated in 2010.

In the Dutch healthcare system, the 8 university hospitals function as tertiary referral centres for high-complex, low-volume care, (including locally advanced rectum and colon carcinoma resections and synchronous metastasectomies) and therefore treat a selected patient group. Of all university hospitals 5 were classified as low-volume hospital en 3 as medium-volume hospitals for colon carcinoma, all except 1 were classified as low- volume hospital for rectum carcinoma. Each university hospital is affiliated with several teaching hospitals, and collaborates in training surgical residents. Most teaching hospitals function as referral centres for medium-complex high-volume surgical care such as locally advanced rectum carcinoma resections. Of all 45 teaching hospitals, 24 were classified as medium-volume hospital and 18 as high-volume hospitals for colon carcinoma, 11 were classified as high-volume hospital for rectum carcinoma. Of all 37 non-teaching hospitals, 14 were classified as medium-volume hospital for colon carcinoma, and all were classified as low-volume hospitals for rectum carcinoma.

Analysis

As treatment and outcome of patients with a colon and rectum carcinoma are different, these groups were analysed separately. All case-mix factors that were predictive for postoperative mortality in univariate logistic regression ($p<0.10$) were included in the multivariate model. Using the coefficients from the multivariate model, an expected mortality was calculated for each patient. The average expected mortality in a group of patients formed the expected mortality rate of that group. The standardized mortality ratio (SMR) was calculated as the quotient of the observed mortality rate, and the expected mortality rate for a group of patients. Confidence intervals were calculated using the standard formulas[11].

For the analysis on hospital level, we calculated the average expected mortality, observed mortality and SMR of all patients treated in a hospital. Hospitals were evaluated individually and also categorized on their teaching status and procedural volume. Differences in expected mortality, observed mortality and standardized mortality rates between different types of hospitals and high and low-volume hospitals were investigated using the one-way ANOVA test. As the total number of hospitals in the Netherlands, and therewith the number of hospitals in each group may be too small to detect any differences between the groups investigated on a hospital level, analyses were repeated on the patient level.

On a patient level, we investigated the differences in expected mortality, observed mortality and standardized mortality rates between all patients treated in university, teaching and non-teaching hospitals, and in high and low-volume hospitals. When differences in expected mortality rates were detected, we further explored which case-mix factors were responsible for the differences in expected mortality rates by repeating the one-way ANOVA test, stratified for each case-mix factor. When the difference in expected mortality disappeared, the case-mix factor was considered to be (partly) responsible. Statistical significance was defined as $p<0.05$. All statistics were performed in PASW Statistics, Rel. 18.0.2009. Chicago: SPSS inc. and Microsoft Excel.

Results

Patients

At March 15th 2011, 90 hospitals (8 university hospitals, 45 teaching hospitals and 37 non-teaching hospitals) registered a total of 8,835 eligible patients with a date of surgery between January 1 and December 31 2010 in the DSCA. After exclusion of patients with multiple synchronous tumours (253 patients) a total of 8,580 patients were included in the analysis, 6,161 patients with colon cancer and 2,419 with rectum cancer. Average procedural volume was 95 patients per hospital (range 14 – 231). The distribution of case-mix factors in the population of patients with colon and rectum carcinoma is specified in table 1. Average observed mortality was 4.5% for colon carcinoma, and 2.3% for rectum carcinoma.

Predictors for postoperative mortality

Age, gender, ASA-classification, Charlson comorbidity index, and urgency of the resection were individual significant predictors for mortality after colon carcinoma resections (Table 2). The C-statistic (95% confidence interval) of the model predicting postoperative mortality after a resection for colon carcinoma was 0.81 (0.78-0.83).
For RC, age, gender, and ASA-classification were significant predictors for postoperative mortality (Table 2). The C-statistic (95% confidence interval) of the model for rectum carcinoma was 0.87 (0.82-0.91).

Differences between hospitals

Colon carcinoma

For colon carcinoma, hospitals' expected mortality ranged from 1.5 to almost 14% [Figure 1a]. The outlier hospital which had an expected mortality of 14% treated more elderly patients and patients with preoperative tumour complications than average. Hospitals' observed mortality varied from 0 to 15.9%, SMR's ranged from 0 to 4.04 (data not shown). We found no differences in expected mortality between non-teaching, teaching and university hospitals or low, medium or high-volume hospitals (table 3).

Rectum carcinoma

For rectum carcinoma, expected mortality ranged from 0.5 to 7.5% [Figure 1b]. Hospitals' observed mortality varied from 0 to 16.7%, SMR's ranged from 0 to 4.87 (data not shown). On the hospital level, non-teaching hospitals had a higher expected mortality than university hospitals (2.44 vs. 1.31%, $p<0.05$), there were no differences in expected mortality between high and low-volume hospitals. We found no differences in unadjusted or standardized mortality rates between the different types of hospitals and volume groups on the hospital level [Table 3].

Table 1: Case-mix factors for colon and rectum cancer patients in the DSCA.

		Colon		Rectum	
		N	%	N	%
N (patients)		6161	72	2419	28
Age (years)	<70	2755	45	1443	59
	70-80	2062	34	715	30
	80+	1337	22	270	11
Gender	Female	2939	48	939	39
Previous abdominal surgery	Yes	2137	35	702	29
ASA classification	I-II	4511	73	2994	83
	III	1457	24	374	16
	IV-V	152	3	26	1
	Missing	41	1	15	1
Charlson score	2+	1231	20	334	14
BMI category	<25	2212	36	945	39
	25-30	1870	30	801	33
	>30	820	13	347	14
	Missing	1259	20	326	14
TNMstage	I	1077	18	712	30
	II	2205	36	646	27
	III	1830	30	763	32
	IV	921	15	240	10
	X	84	1	30	1
Preop radiotherapie	5x5 gy	-	-	1132	47
	>60 gy	-	-	156	6
	Chemoradiation	-	-	674	28
Preop tumourcomplication	Fistula	139	2	15	1
	Obstruction	747	12	57	2
	Else	484	8	88	4
	Missing	209	3	88	4
Urgency of resection	Urgent	728	12	33	1
	Acute	444	7	20	1
Surgical procedure	Right hemicolectomy	2881	47	-	-
	Left hemicolectomy (+transversum)	796	13	-	-
	Sigmoid	1414	23	-	-
	(L)AR	834	14	1613	67
	APR	-	-	722	30
	Else	236	4	84	3
Laparoscopic resection	Laparoscopic (+conversion)	2296	37	888	37
	Conversion to open	366	6	117	5
Extended resection	Locally advanced tumour	598	10	172	7
	Metastasectomia	166	3	72	3

ASA = American Society of Anesthesiologists classification
BMI = Body Mass Index
TNM = Tumour Node Metastasis system
(L)AR = (Low) Anterior Resection
APR = abdomino perineale resectie

Table 2: casemix-factors included in the multivariate logistic regression model for mortality after colon and rectum carcinoma resections.

		Colon		Rectum	
		OR	95% C.I	OR	95% C.I
Age	<70	1.00		1.00	
	70-79	2.06	1.43-2.99	3.15	1.51-6.58
	80+	5.10	3.56-7.29	3.55	1.54-8.22
Gender	Female	0.68	0.52-0.88	0.44	0.22-0.88
Charlson score	2+	1.38	1.04-1.83	1.81	0.95-3.46
ASA score	I-II	1.00		1.00	
	III	2.44	1.83-3.25	4.79	2.50-9.16
	IV-V	7.47	4.72-11.82	6.24	1.72-22.61
	Missing	1.13	0.26-5.02	8.46	0.99-72.05
TNM Stage	I	1.00		1.00	
	II	0.90	0.60-1.35	0.89	0.42-1.90
	III	1.00	0.65-1.52	0.71	0.33-1.53
	IV	1.53	0.97-2.41	1.39	0.53-3.68
	X	1.94	0.85-4.45	1.24	0.29-5.26
Radiotherapy	None			1.00	
	5x5 gy			0.55	0.29-1.05
	>60 Gy			0.32	0.07-1.46
	Chemoradiation			0.32	0.11-1.00
Tumourcomplication	None	1.00		1.00	
	Perforation	1.82	0.89-3.73	-	
	Obstruction	1.25	0.78-1.99	1.43	0.30-6.94
	Else	1.21	0.78-1.88	2.45	0.85-7.05
	Missing	0.96	0.45-2.05	2.56	0.88-7.49
Urgency	Elective	1.00		1.00	
	Urgent	1.61	1.06-2.46	2.16	0.47-9.92
	Acute	2.13	1.26-3.59	2.74	0.38-19.69
Procedure	Right hemicolectomy	1.00			
	Left hemicolectomy	1.37	0.97-1.95		
	Sigmoid resection	0.53	0.39-0.73		
	Else	1.23	0.69-2.20		
Extended resection	Local	1.45	0.98		

CI = confidence interval
OR = Odds ratio
ASA = American Society of Anesthesiologists classificaion
TNM = Tumour Node Metastasis system
Bold printed numbers are significant odds ratios ($p<0.05$)

Differences between patients treated in different types of hospitals and volume groups.

Colon Carcinoma

Expected mortality varied between individual patients from 0.4 to 70.8%. Average expected mortality of patients treated in non-teaching, teaching and university hospitals and in patients treated in low-, medium- and high-volume hospitals are presented in table 4.

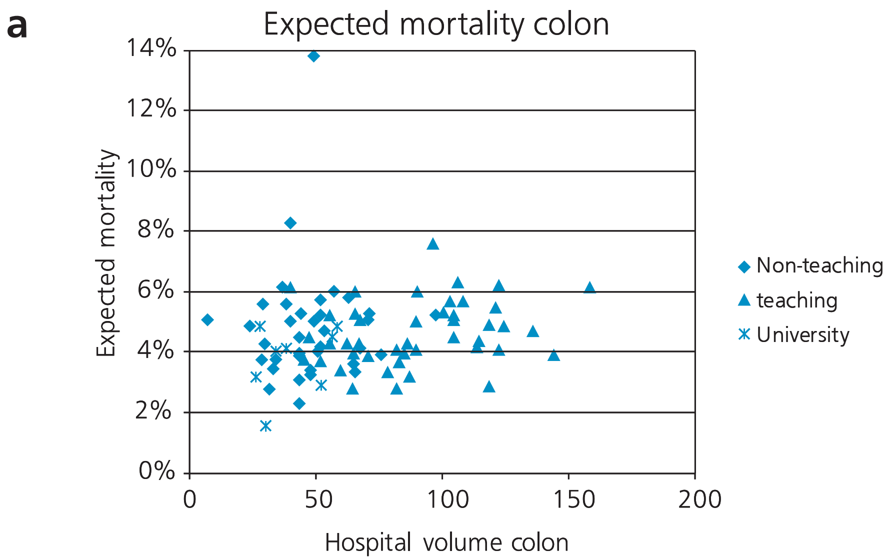
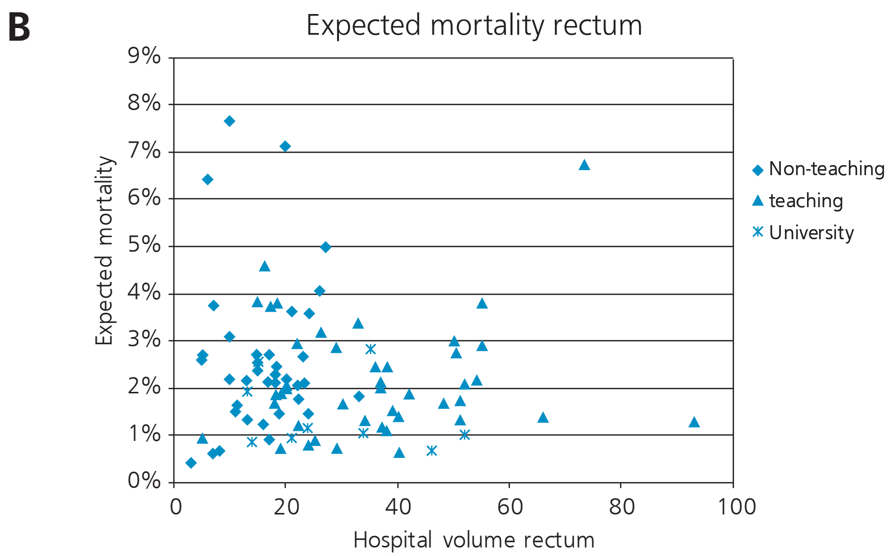


Figure 1a: Expected mortality colon carcinoma



Figuur 1b: Expected mortality rectum carcinoma

Average expected mortality did not differ between patients treated in university, teaching or non-teaching hospitals, though the observed mortality was higher in non-teaching hospitals. When outcome was adjusted for case-mix, we found no significant differences.
Expected mortality in patients treated in low-volume hospitals was significantly higher than in high-volume hospitals (5.0 vs. 4.3%, $p<0.05$). Despite the differences in expected

Table 3: Differences in Expected mortality on hospital level

	N	Mean **expected** mortality (%)	CI 95%	Mean **observed** mortality (%)	CI 95%	SMR	CI95%
Colon							
Non-teaching	37	4.76	4.41-5.11	5.07	3.52-6.61	1.22	0.88-1.57
Teaching	45	4.49	3.97-5.01	4.64	3.59-5.69	0.94	0.79-1.09
University	8	4.92	3.37-6.48	4.14	3.07-5.21	0.91	0.07-1.75
<50	31	5.04	4.27-5.81	5.07	3.52-6.61	1.13	0.74-1.52
50-100	41	4.50	4.16-4.84	4.64	3.59-5.69	1.03	0.81-1.25
100+	18	4.27	3.86-4.68	4.14	3.07-5.21	0.97	0.71-1.23
Rectum							
Non-teaching	37	2.44*	1.05-3.83	2.65	2.10-3.20	0.79	0.39-1.20
Teaching	45	2.17	1.44-2.90	2.22	1.86-2.58	0.97	0.62-1.32
University	8	1.32*	0.28-2.92	1.33	0.74-1.92	1.06	0.43-2.55
<50	78	2.18	1.43-2.92	2.28	1.97-2.59	0.89	0.60-1.17
50-100	12	2.39	0.74-4.03	2.53	1.53-3.53	1.03	0.38-1.69

*Non-Teaching vs University hospital: p<0.01

SMR: Standardized Mortality Ratio = Observed mortality/Expected mortality

Table 4: Differences in Expected mortality on patient level

	N	Mean **expected** mortality (%)	95% CI	Mean **observed** Mortality (%)	95% CI	SMR	95% CI
Colon							
Non teaching	1760	4.8	4.4-5.1	5.5*	4.5-6.7	1.18	0.97-1.43
Teaching	4080	4.4	4.2-4.6	4.1	3.5-4.7	0.93	0.80-1.08
University	321	4.8	4.0-5.6	3.7*	1.7-5.8	0.78	0.42-1.32
<50	1149	5.0@	4.6-5.4	5.3	4.0-6.6	1.06	0.82-1.36
51-100	2830	4.5	4.3-4.7	4.5	3.7-5.3	1.00	0.84-1.19
100+	2131	4.3@	4.0-4.5	4.1	3.3-4.9	0.96	0.78-1.18
Rectum							
Non teaching	589	2.7*	2.3-3.1	2.6	1.3-3.8	0.95	0.57-1.57
Teaching	1591	2.3$	2.0-2.5	2.3	1.6-3.1	1.03	0.74-1.42
University	239	1.3*$	0.9-1.7	1.3	0.0-2.7	0.95	0.31-2.95
<50	1717	2.2#	1.9-2.4	2.2	1.5-2.8	1.00	0.72-1.38
50+	702	2.6#	2.1-3.0	2.6	1.4-3.7	1.00	0.63-1.59

*Non-Teaching vs University hospital: p<0.01

$ Teaching vs University hospital: p<0.01

@ <50 vs 100+ p<0.01

<50 vs 50+ p<0.05

SMR: Standardized Mortality Ratio = Observed mortality/Expected mortality

mortality, there were no differences in standardized, nor in unadjusted mortality rates between patients treated in different volume groups.

The differences in expected mortality between different groups of patients were further explored. Differences in expected mortality between high, medium and low-volume hospitals disappeared when patients were stratified for Charlson score, ASA- classification and urgency of the resection, meaning that differences in expected mortality were mostly explained by differences in comorbidity score and urgency of the resection (data not shown).

Rectum Carcinoma

Expected mortality varied between individual patients from 0.0 to 52.5%. The expected mortality was higher in patients treated in non-teaching and teaching hospitals than in patients treated in university hospitals. (2.7 and 2.3 vs. 1.3% respectively, p<0.01). Also, patients treated in high-volume hospitals had a lower expected mortality than patients treated in low-volume hospitals (1.6 vs. 2.2% p<0.05). There were no differences in observed or SMR between different types of hospitals. Despite the differences in expected mortality, there were no differences in standardized, nor in unadjusted mortality rates between patients treated in different volume groups for rectum carcinoma. None of the individual case-mix factors could explain the differences in expected mortality between patients treated in university, teaching and non-teaching hospitals or high and low-volume hospitals (data not shown).

Discussion

This study confirms the essential role of case-mix adjustments in clinical auditing for colorectal cancer. For individual hospitals, expected mortalities varied between 1.5 and 14% for colon cancer and from 0.5 and 7.5% for rectum cancer resections. Patients treated colon cancer in low-volume hospitals had a higher expected mortality than patients treated in high-volume hospitals, due to an unfavourable case-mix. These differences in expected mortality were mostly explained by low-volume hospitals treating patients with more comorbid diseases, with a higher ASA classification and more often in an urgent or acute setting. However, for rectal cancer resections expected mortality was higher in patients treated in high-volume hospitals and patients treated in non-teaching and teaching hospitals had a higher expected mortality than those treated in university hospitals. Despite these differences in case-mix, we found no differences in risk-adjusted outcome between patients treated in different types of hospitals.

One of the merits of the growing number of national audit programs is the United States and Europe is the increasing availability of prospectively collected case-mix information, which is needed to investigate the risk for postoperative mortality after colorectal cancer operations[12]. For this study we used the 2010 data from the Dutch Surgical Colorectal Audit, which contains an extensive set of case-mix variables. Based on this dataset we identified a risk profile for colon and rectum carcinoma resections separately, consistent with previous risk-adjustment models developed on different data-sets[13, 14].

Previous studies have described variations in case-mix distribution between teaching and non-teaching hospitals, and high- and low-volume hospitals with slightly different results. Zhang[5] reported that elderly patients with a low income, a high comorbidity index or tumour stage, were less likely to be treated in high-volume hospitals. Friese[4] investigated surgical oncology patients and found a younger population with a high comorbidity index and more patients with disseminated disease in the major teaching hospitals and high-volume hospitals. Khuri[6] showed that teaching hospitals serve a younger population, but have more emergency cases in general surgery. As these studies originate from different health care systems, it is difficult to assess their relevance for the situation in European countries. Even within Europe case-mix distribution between different types of hospitals can vary by country. To get more insight in the distribution of case-mix between different hospitals or countries, an integrated measure for case-mix is needed.

The present study introduces a commonly used measure for risk-adjustment: the expected mortality, as a measure for the integrated effect of case-mix factors, giving an insight in how high-risk patients are distributed in our healthcare system. We showed that there is considerable variation in risk-profile of patients treated in different hospitals in the Netherlands: in non-teaching, teaching and university hospitals, and in high and low-volume hospitals. Moreover, we showed marked differences in expected mortality between the individual hospitals, varying from 1.5 to 14% for colon cancer patients and from 0.5 and 7.5% for rectal cancer patients (Figure 1a and 1b).

As in many countries, the political focus in the Netherlands is increasingly on outcome measurement and concentration of care in specialized high-volume centres. However, we found no differences in observed or standardized mortality between patients treated in high, intermediate or low-volume hospitals in our study. We did find a higher unadjusted mortality rate among patients treated in non-teaching hospitals, but, after adjustment for case-mix variations, the SMR was not higher than for patients treated in teaching or university hospitals. Also, considerable variation in observed and standardized mortality between individual hospitals was found, irrespective of teaching status or procedural volume. Therefore, concentration of care should preferably be guided by outcomes of care of individual hospitals as measured in nation-wide clinical audits (outcome-based referral)[15, 16]. The variations in outcome between individual hospitals will be further investigated in a different study. In this context, case-mix adjustments based on hospitals' expected mortality are essential for reliable outcome comparisons.

Limitations

The results of this study have to be interpreted in the light of several limitations. First, analyses were based on hospital specific data from one registration year, 2010. Differences in expected mortality between individual hospitals may change slightly due to random statistical variation when more registration years are evaluated, although we expect the observed differences between types of hospitals to remain similar. Moreover, the number of patients treated in university hospitals, and the number of university hospitals in the Netherlands was relatively low. The expected mortality found for rectal resections was lower in university hospitals, than in teaching and non-teaching hospitals. Although it is a common perception that university hospitals perform more complex and therefore more high-risk procedures, procedural complexity had only a very small effect on the expected mortality. Age, gender and ASA-classification were the most important case-mix factors influencing the expected mortality for rectal resections. As university hospitals in the Netherlands are designated tertiary referral centres, preferably performing only high complex operative procedures, the majority of colorectal resections are performed in teaching and non-teaching hospitals. In an elective setting, young patients with more advanced cancer may more often choose to be treated in, or are more often referred to university hospitals, whereas elderly patients with a high comorbidity score will more often go to the nearest (non-)teaching hospital. Even though we found that none of the individual case-mix factors was responsible for the differences in expected mortality for rectum carcinoma, the combination of factors could explain the low expected mortality for university hospitals found in our study.

Conclusion

The present study shows that high-risk colorectal cancer patients in the Netherlands are mostly characterised by an older age, comorbidity and an indication for non-elective resection. High-risk patients are not evenly distributed between individual and groups of hospitals. Using expected mortality as an integrated measure for their case-mix gives insight in the hospitals where high-risk patients go, which is important for the targeting of quality improvement programs. The large variation in expected mortality between individual hospitals, hospital types and volume groups underlines the need for risk-adjustment when comparing hospital performances, or even when comparing performances on a more international level as is intended in the EURECCA project of the European Society for Surgical Oncology[12]. A complete, population based dataset, and a uniform registration and methodology for case-mix adjustments are imperative for valid comparison of outcome of care between countries or healthcare systems[17].

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